RESEARCH REPORT

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HYDRAULIC HEAD MEASUREMENTS WITH THE MULTIPLE CELL TENSIOMETER

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TABLE OF CONTENTS

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Details of Construction

Details of construction for the instrument were given in the article "Multiple tensiometer for determining the vertical component of the hydraulic gradient in soil," Soil Science Society of America Proceedings 18:7-10 (1954). (Reprints no longer available)

The following errata should be noted. In Table 1, the dimensions for Part A, the point, should be 1 1/4 in. dia. by 2 1/2 in. long. In figure 1 for Part A also, the counterbore that has a diameter of 1 in. should extend 1 1/8 in. into the point. This additional length of counterbore is required to prevent Part D from bottoming in the counterbore.

The following modifications have been introduced in recent units constructed at the Salinity Laboratory. The brass sleeve, Part L in Table 1, may be omitted if the neoprene sleeve, Part O, is changed to have the following dimensions: 1/16 in. I.D. by 1/8 in. wall. One end of the glass manometer tube, Part I, is then reduced in diameter by drawing in a flame until the outside diameter is about 1/8 in. This change eliminates one part and makes a more satisfactory joint.

It is most important that "O" rings be NEOPRENE. Other commonly used compositions develop surface cracks in the presence of ozone and are not acceptable for this application.

While not entirely necessary, it has been quite convenient for most field applications to substitute for the solid neoprene stopper designated as Part N in the table, a 1-hole stopper with a piece of 1/8 in. copper tubing, a piece of neoprene tubing and a spring pinch clamp. This combination air-trap closure facilitates filling the instrument with water and resetting to approximately the same scale reading after a filling operation.

Filling with Water

To avoid air bubbles in the system always use freshly boiled and cooled water for filling the multiple cell tensiometer. For this operation also it is quite convenient to make a syringe from a 25 ml. No. 2006, Becton Dickinson Co., Rutherford, N. J. rubber bulb. This bulb is commonly sold in snake bite kits at drug stores. Provide the bulb with a stem made from a piece of 0.109 in. O.D. copper tubing and a brass adapter plug. By use of this syringe, water can be supplied at the air trap under pressure so as to fill the porous cup and the glass capillary tube and then by releasing the hand pressure on the rubber

bulb a vacuum pressure can be applied to the system. Whenever the tensiometer is refilled, the operator should look at the glass capillary to observe the amount of air that is displaced from the porous cup. A small air bubble can be expected to come from the neoprene joint between the glass and the copper tubing. The suction range for reliable operation of the instrument can be judged from the amount of air coming from the cup during refill.

The tensiometer should have all cups refilled 12 to 24 hours before taking a set of readings if the unit has stood for a number of days prior to the readings. After filling the manometers, the heavy walled rubber bulb can be used to pull the mercury columns back up to approximately the positions on the scale they had before filling. This will minimize disturbance to the soil-water system by the filling operation. The mercury column should be pulled up slowly, otherwise, the mercury may not displace the water from the glass tube. This undisplaced water may collect and cause a separation in the mercury column.

Setting the Scale Zero

It is convenient to use the soil surface as the hydraulic head datum and an index mark should be made on the tensiometer tube to indicate the depth to which the tensiometer should be installed in the soil. First, stand the tensiometer in water with the water surface at the index mark. Water emersion can be accomplished in a metal or plastic pipe. Fill the manometer reservoir with clean mercury, fill the tensiometer with freshly boiled water. Alternating pressure and suction at the air trap helps to displace air at the neoprene joint at the top of the glass tube. After filling and with the instrument standing in water to the depth of the index mark, the mercury columns should all come to rest at the level of the zero of the scale. The scale can be moved to meet this condition.

Suction Test

The following test for vacuum tightness of the system can be made only when the outsides of the porous cups are in air. Fill the various tensiometer units with freshly boiled water and pull the mercury columns up to near the top of the scale, 600 to 800 millibars. An aspirator vacuum pump can be used. The mercury column should remain without dropping. A second pull-up may be necessary, because any water around the outside surface of the porous sections will move inside and lower the mercury columns. This test is more significant if it can be conducted without evaporation at the exterior surface of the porous sections because rapid evaporation may obscure a small leak. A wrapping of any thin impermeable sheet material can be used to prevent evaporation.

If a suction bulb or aspirator pump is not available for applying the test vacuum, evaporation from the cups can be used to pull up the mercury columns.

Installation in the Field

The following equipment and supplies are needed: Viehmeyer soil sampling tube, driving hammer, plumb bob, 1/8 in. brass or steel rod for tamping the soil around the tensiometer cup, enough air-free water to fill the tensiometer, enough additional water to fill the soil tube hole, and enough clean mercury to fill the reservoir.

The cutting point for the soil sampling tube should have a maximum diameter of 1.250 in. (tolerance, plus 0.015 minus .000). The soil tube should be six inches longer than is required for the depth of the tensiometer.

The plumb bob, which can consist of a rock on a string, can be used to keep the soil tube nearly vertical. Drive the soil tube carefully so as not to make the hole larger than the point. The tube should be emptied of soil at about every 30 cm. depth interval. Use extreme care not to enlarge the hole unnecessarily. Make the soil hole at least 15 cm. deeper than the tensiometer point will be set. Then remove the soil tube, free it of soil, reinsert it in the hole and fill the soil tube with water. Then remove the soil tube, thus leaving the hole filled with water. Immediately thereafter carefully push the tensiometer into the water filled hole to the depth of the index mark on the tube. If some obstruction such as a rock or a root is encountered in making the hole a new site should be selected and another attempt made to get a perfect hole.

After installing the tensiometer, use the thin brass rod to tamp the soil adjacent to the tensiometer tube to a depth of a few centimeters, especially if the tensiometer site is to be basin irrigated.

Scale Reading Procedure

If hydraulic-head changes in a soil profile extending over a number of days are required, it is preferable to take readings at about the same time of day. When possible it is believed that early morning is the best time. Use a small transparent square that guides on the manometer support to read the hydraulic head to the closest centimeter on the tensiometer scale. Suction head values can be obtained, if desired, from the hydraulic head reading by substracting the distance from the index mark to the middle of the porous cup.

The following references give examples of the nature and use of hydraulic head readings:

Richards, L. A. 1955. Retention and transmission of water in soil. Yearbook of Agriculture (USDA), 1955. 144-151.

Ogata, Gen and Richards, L. A. 1956. Water content changes following irrigation of bare field soil that is protected from evaporation. Soil Sci. Soc. Amer. Proc. 21:355-356.

Removal of the Multiple Tensiometer from a Field Site

If the soil is wet, the unit can be lifted out without trouble. If a firm vertical pull with the hands does not loosen the tensiometer, the soil may be shoveled away from the surface where it is most likely to sieze. If this does not release the unit, fill the hole around the tensiometer with water and allow this to loosen the soil to a sufficient depth for the removal. Several nearby soil tube holes may hasten the soak out.

Troubles

Pushing the tensiometer into the soil with a stone along the side of the hole may break a cup. If this trouble is suspected, a vacuum test with the suction bulb will reveal the difficulty.

If a small leak is found after the field installation, the operator may try tightening the nut on the pull rod to see if this will correct the situation. A vacuum test with the tensiometer installed in moist soil in the field, however, is not conclusive in demonstrating leaks because when the vacuum is pulled up, soil water tends to move into the cups and it is sometimes difficult to distinguish this cause of manometer change from a leak. Each time the tensiometer is filled with water, the operator should observe the passage of any air from the porous cell down through the glass mercury manometer tube. Experience will indicate volumes of air that may be normally expected to diffuse into the system through the neoprene seals. If air leakage is excessive, the unit will need to be returned to the shop for repairs because it is difficult to disassemble and replace cups or seals in the field.

A large diurnal swing in the scale readings sometimes indicates poor contact between the porous cups and the soil in the profile. The only remedy for this is to insert the instrument in a new hole.

The time required for the manometers to come back to a previous reading, after a filling operation, provides information on the overall reliability and significance of the readings from a given installation and instrument.